USING CERAMIC TILES ON THE WALLS OF A BUILDING AS MITIGATION MODEL FOR URBAN HEAT ISLAND

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Abstract

Urban areas typically have surface materials, such as roofing and paving, which have lower albedo than those in rural settings. As a result, built up communities generally reflect less and absorb more of the sun's energy. This absorbed heat increase surface temperatures and contributes to the formation of surface and atmospheric urban heat island. Another property that influences heat island development is a material's heat capacity, which refers to its ability to store heat. Many building materials such as steel and stone have high heat capacities than rural materials such as dry soil sand. The Ceramic tiles have one side polished. That side is a perfect reflector and a poor absorber of heat. This study sought to investigate the use of ceramic tiles on the walls of a building as a good mitigation model for urban heat island. The study was experimental. In the laboratory, ceramic tiles were mounted on a stand. Heat from the halogen lamp of 500 watts was found on non-reflective side of the tiles. Thermometers were placed on the reflected sides of the tiles and measurements taken. This experiment was reversed. Graphs were drawn and analyzed. From the result of the study, it was observed that ceramic titles placed at the exterior walls of the building will raise a good mitigation to urban heat island effect.

KEY WORDS: Albedo, Heat Island, Ceramic Tiles, Mitigation, Heat Capacity.

INTRODUCTION

The temperature difference in a city and its surrounding country side is due to what happens to the energy from the sun in the two environments. The larger the cities the bigger the temperature difference. Urban surfaces are usually warmed-up by absorption of solar radiation and by virtue of the high heat capacity characteristics they posses, they act as giant heat reservoirs. As a result of this high day time temperature, the urban island can easily be seen via thermal remote sensing. The term heat island depicts the increased air and surface temperature in a given urban area as compared with their surrounding rural areas.

Compounding the albedo difference in a city is the underlying morphology of cities (Golany, 1996). Paved surfaces including parking lots and roadways often constitute a significant fraction of the urban fabric. Although there is typically more paved surface area than rooftop area, changes in pavement albedo are complicated by a lower sky view factor. That is, some of the radiation reflected from a paved surface is intercepted by building walls. Furthermore, a non-trivial fraction of paved surfaces are commonly covered by vehicles, thus reducing the effectiveness of any pavement albedo modification strategy.

When solar radiation is reflected from a street surface some of it escape the urban canopy, but some, depending upon sky view factor, is intercepted and partially absorbed by exterior building walls. So, the effective albedo of a city can be significantly lower than that of the rural countryside and even lower than the albedo of any individual component surface (Sailor and Fan, 2002). It is important to note that reflective roofs becomes less reflective with age, due to the fact that large part are soiled from soot and other particulates (Berdahl et al., 2002) much of the original albedo can be recovered, however, through periodic washing of the roof surface.

CONFORT TEMPERATURE IN RELATION TO INDOOR AND OUTDOOR WEATHER CONDITIONS

Most building in the Europe are naturally ventilated and during the summer months will be free-running (i.e. not heated or cooled). The temperatures in such buildings will change according to the weather outdoors, as well the clothing of the occupants. Even in air conditioned buildings the clothing has been found to change according to weather (de Dear and Brager, 2002). As a result, the temperature people find comfortable indoors also changes with the weather (Humpherys, 1981). Customarily indoor temperature are not fixed, but are subject to gradual drift in response to change in both out-door and indoor conditions and are modified by climate and social custom. a sudden departure imposed upon the occupants is likely to provoke discomfort and complaint while a similar change occurring gradually would not provoke complaint.

The diverse technical approaches to achieve a good indoor climate are often accompanied by complaints from workers about many types of discomfort and dissatisfaction, which are summarized as the “sick building syndrome”.

One German investigation of this phenomenon, the so-called “Prochima Project” reached the conclusion that although buildings with air-condition maintain an objective better indoor climate, and they are subjectively rated lower than naturally ventilated working condition by the majority people. This rating is significantly affected by; the degree to which an individual can determine the conditions prevailing at his work place and the degree of maintenance of the technical service system.

Out-door climate is equally affected and its consequences are numerous.

Surface heat island degrades water quality by thermal pollution.

Pavement and rooftop surfaces that reach temperatures of 50^0 to 90^0F (27^0 to 50^0C) higher than air temperature transfer this excess heat to storm-water. When the rain came before the pavement has a chance to heat up, runoff temperatures from the rural and urban areas differed by less than 4^0 F (2^0 C) (Roa-Espinosa et al., 2003). This heated stored water generally drains into storm sewers and raises water temperatures as it is released into streams, rivers, ponds and lakes. A study in Arlington, Virginia, recorded temperature increases in surface waters as high as 8^0F (4^0C) in 40 minutes after heavy summer rain (EPA, 2003). These causes rise in water temperature which affects all aspects of aquatic life, especially the metabolism and reproduction of many aquatic species. Rapid temperature changes in aquatic ecosystems resulting from warm storm water runoff can be particularly stressful. Brook Trouts for example, experiences thermal stress and shock when the water temperature changes more than 2^0 to 4^0 F (1^0 to 2^0C) in 24 hours (EPA, 2003)

It is known that some building materials have high heat capacities, while others have low heat capacities.

Tiles are mostly made from porcelain fired ceramic with a hard glaze pottery with other materials such as glass, stone, and metals. They are often used to cover walls, floor covering and they range from simple square tiles to complex mosaic. Tiling stone is a typical marble slate. Thinner tiles can be used on walls than on the floors which require thicker and more durable surfaces. It can some times refer to similar units made from light weight materials such as wood, typically used for walls and ceiling application. This study seeks to investigate the use of ceramic tiles on the walls of a building as a good mitigation model for urban heat island.

MATERIALS AND METHOD

A brief description of the ceramic tile is necessary. The ceramic tile is a thin square slab of glazed pottery for covering floors or walls of a building. They are mostly made from porcelain, fired ceramic with a hard glaze. They are described as products made from inorganic materials having non-metallic properties. They are durable in chemical, mechanical and thermal ways e.g. water absorption, stain resistance and breaking strength. Ceramic tile coverings prevent formation of mould in the exterior walls of the building with high humidity.

In this study the digital thermometer was used. Digital thermometer has a long probe sensor for detecting temperature variation. It is very sensitive and was calibrated electronically. It covers a wide range of temperature from -50^{0}C to +300^{0}C (-58^{0}F to +572^{0}F). The measurements were displayed on liquid crystal diode (LCD) for easy reading.

Also used for the experiment was the halogen lamp and a wooden pipe. The halogen lamp also known as a tungsten halogen or quartz iodine lamp is an incandescent lamp. It is a light bulb consisting of quartz bulb and a tungsten filament. The bulb contains iodine vapour. This lamp's rating is 500 watts. In the laboratory setting, it represented the source of heat required for this experiment. Wooden pipe is a pipe made up of wood. Wooden pipe, as an insulator is needed in this experiment to provide guided pathway to the light beam from the halogen lamp to its target.

The use of electric generating plant was necessary. This is a gasoline electric generator used in the laboratory to power the halogen lamp. For the experiment, ceramic tile was place in between and in contact with the wooden pipes A and B. Heat from the halogen lamp was focused on non-reflective side of the tile through the wooden pipe A. Digital thermometer was place on the reflective side of the tile through the wooden pipe B. The halogen lamp was powered by an electric generating plant. The thermometer readings were taken and recoded. The tile position was exchanged and measurement also taken and recorded. This experiment was repeated several times, and the measurements recorded.

Figure 1 Ceramic Tile

RESULTS OF THE STUDY

Figure 2 shows the plot of day one experimental results of experiment one using ceramic tiles on the walls of a building. It shows that the highest temperature 33.5^{o}C was recorded around

3.0pm and the least temperature recording was 27.2ºC around 4pm. The laboratory room temperature was 28.7^{0}C.

Figure 3 is the result of day two experimental results of experiment one using ceramic tiles. It shows that the temperature at 12 noon and 1 pm are the highest 28.4ºC while the least temperature is 27.3ºC was recorded at 4 pm.

The result showed in Figure 4 is the temperature recording of the third day experiment one using ceramic tiles. It shows that the highest temperature of 28.2ºC was recorded around 12.00 noon and the least recording of 27.1ºC was recorded around 4.00 pm.

Figure 5 is the result of day one of experiment two using ceramic tiles. The highest temperature of 40.1ºC was recorded at 12 noon and the least temperature of 33.6º C was also recorded around 9.00 am. This situation is not far-fetched for day 2 and day 3 of experiment two. The experiment recorded the highest temperatures of 39.8ºC and 40.2^{0}C around 12 noon and 33.9ºC were recorded around 8.00 am, (see Figures 6 and 7) respectively. The least temperatures of 32.7^{0}C in figure 6 were recorded around 8.00am and 33.9^{0}C in figure 7 was recorded around 8.00am.

DISCUSSION

The use of ceramic tiles on the exterior walls as represented experimentally yielded a better result as a mitigation model because ceramic tiles are poor absorbers of heat and the shiny surface reflects sun radiation that strikes on it away, thereby decreasing the heat that would have been absorbed. This keeps the interior part of the building cool. This will act in opposite direction during the winter. It will reflect off the cold weather and keeping the interior warm. All these were observed and verified from the results of the experiment, using the two surfaces of a ceramic tile. An example is the study conducted by (Kikegawa et al.2006) who have carried out computer simulation to report that the reduction of anthropogenic heart and planting vegetation on the side walls of building could reduce air temperature up to 1.2^{0}C and reduce space cooling energy demand up to 40%. Also, (Ashie et al. 1999) used computer modeling and reported air temperature reduction of 0.4 to 1.3^{0}C with building cooling energy savings of as much as 25% through planting vegetation.

The initial temperature over the three days experiment was 27.6ºC. Looking at the temperature distribution of the result, the temperature is lower when the heat is applied on the reflective side than when the heat is applied on the non-reflective side. Inside the house, the temperature will be cooler if the ceramic tiles were used to cover the outer walls of a building. The sun's radiation falling on the reflective side of the ceramic tiles will be reflected away. This proved that ceramic tiles will be a good mitigation model for Urban Heat Island.

Table 1 Results of experiment 1 Day 1 on Cool walls II (Reflective side)

Time	**Temperature ºC**
8.00 am	27.6
9.00 am	27.7
10.00 am	27.8
11.00 am	27.8
12.00 noon	28.3
1.00 pm	28.2
2.00pm	28.2
3.00 pm	28.5
4.00pm	27.2

Table 2 Results of experiment 1 Day 2 on Cool walls II (Reflective side)

Time	Temperature °C
8.00 am	27.5
9.00 am	27.7
10.00 am	28.0
11.00 am	28.1
12.00 noon	28.4
1.00 pm	28.4
2.00pm	28.3
3.00 pm	27.9
4.00pm	27.3

Table 3 Results of experiment 1 Day 3 on Cool walls II (Reflective side)

Time	Temperature °C
8.00 am	27.4
9.00 am	27.4
10.00 am	27.5
11.00 am	27.6
12.00 noon	28.2
1.00 pm	28.1
2.00pm	28.0
3.00 pm	27.8
4.00pm	27.1

Table 4 Results of experiment 2 Day 1 on Cool walls II (Non-reflective side)

Time	Temperature °C
8.00 am	33.7
9.00 am	33.6
10.00 am	36.2
11.00 am	38.4
12.00 noon	40.1
1.00 pm	39.8
2.00pm	38.3
3.00 pm	37.1
4.00pm	36.3

Table 5 results of experiment 2 Day 2 on Cool walls II (Non-reflective side)

Time	Temperature °C
8.00 am	32.7
9.00 am	33.8
10.00 am	34.9
11.00 am	35.9
12.00 noon	39.8
1.00 pm	38.5

2.00pm	37.6
3.00 pm	36.4
4.00pm	35.2

Table 6 Results of experiment 2 Day 3 on Cool walls II (Non-reflective side)

Time	**Temperature °C**
8.00 am	33.9
9.00 am	34.5
10.00 am	35.2
11.00 am	37.3
12.00 noon	40.2
1.00 pm	40.0
2.00pm	38.3
3.00 pm	36.5
4.00pm	34.7

Figure 2 Graph of the results from ceramic tiles experiments.

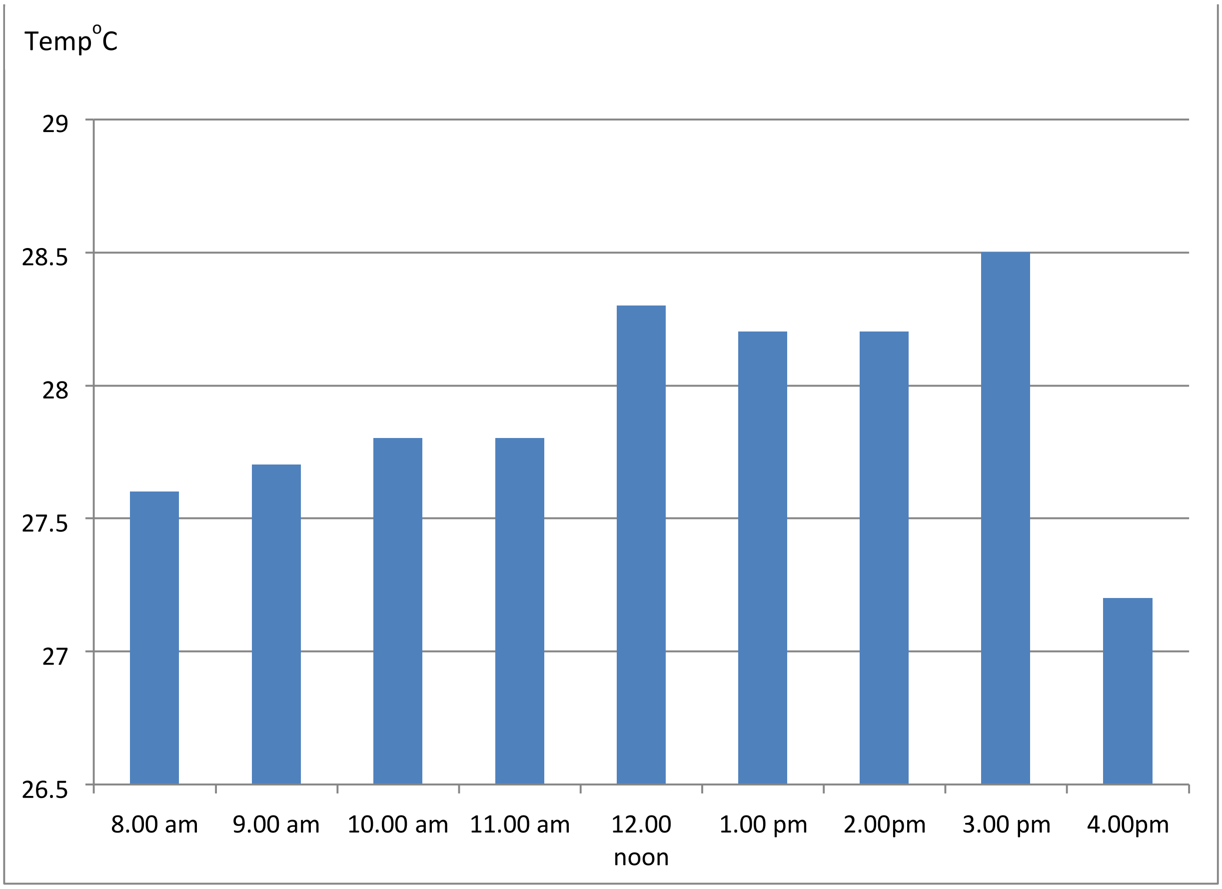


Figure 3 Graph of results from ceramic tiles experiment.

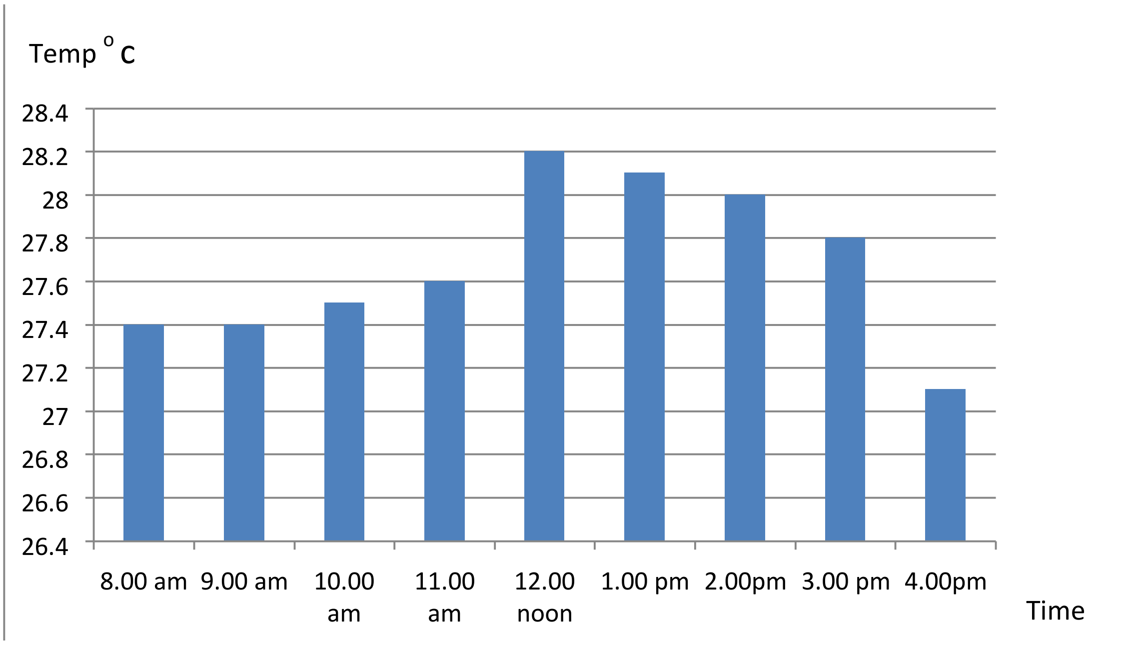


Figure 4 Graph of results from ceramic tiles experiment.

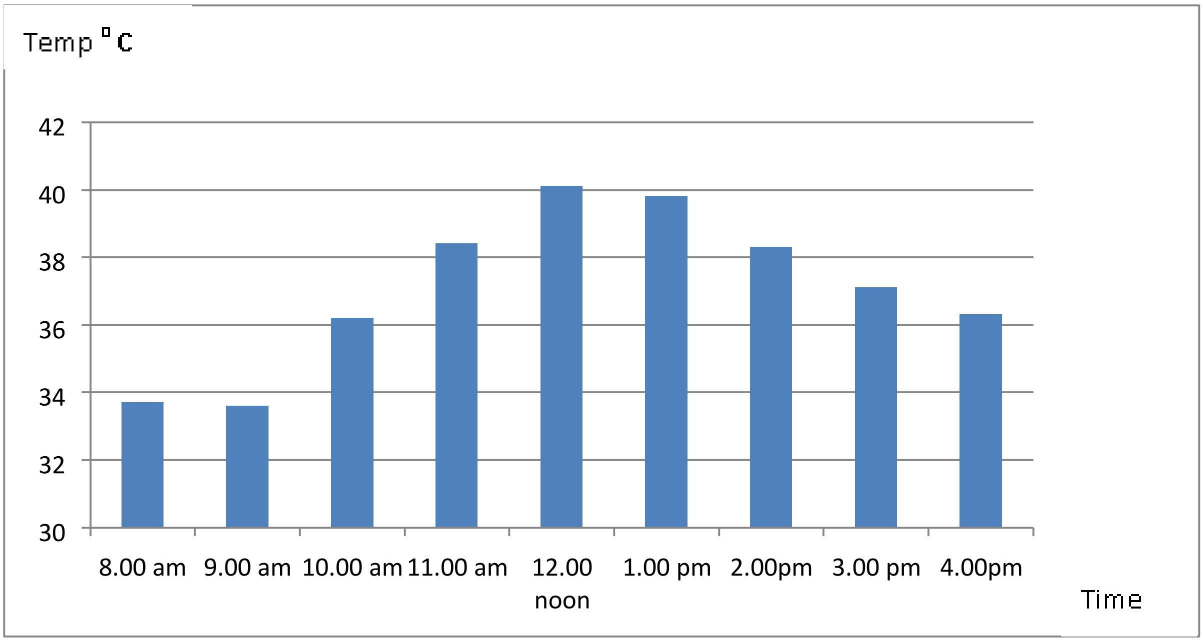


Figure 5 Graph of results from ceramic tiles experiment.

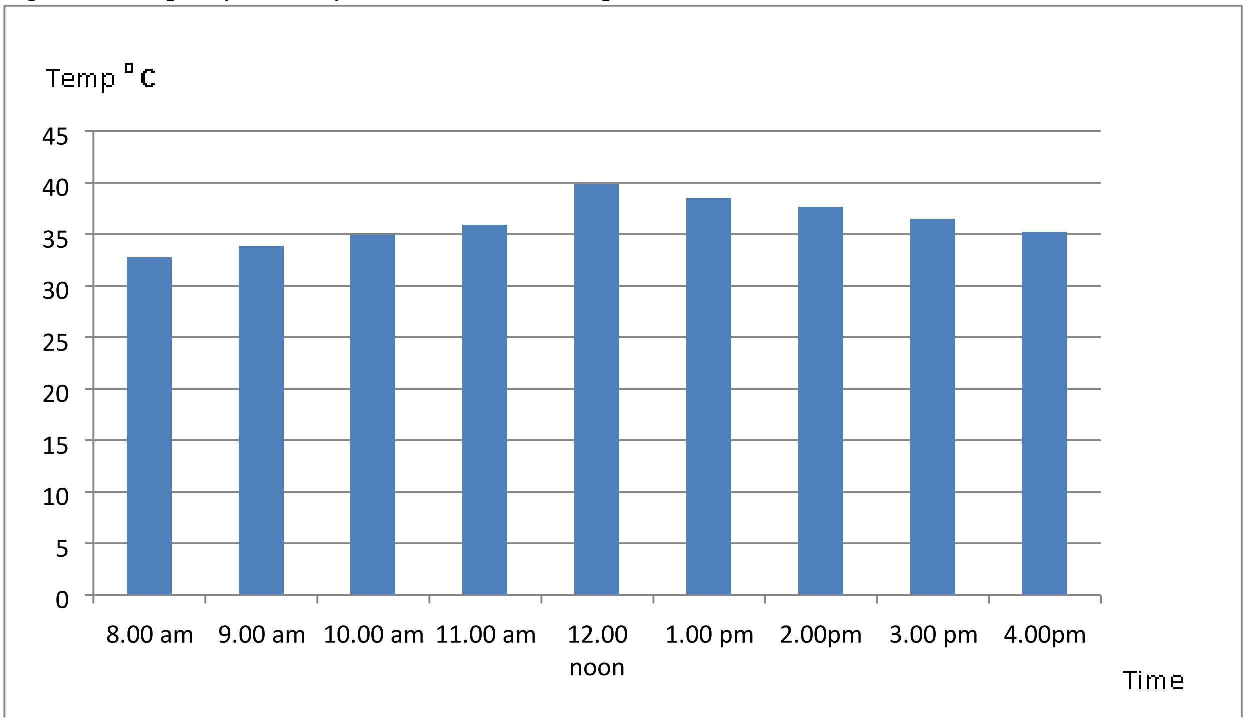


Figure 6 Graph of results from ceramic tiles experiment

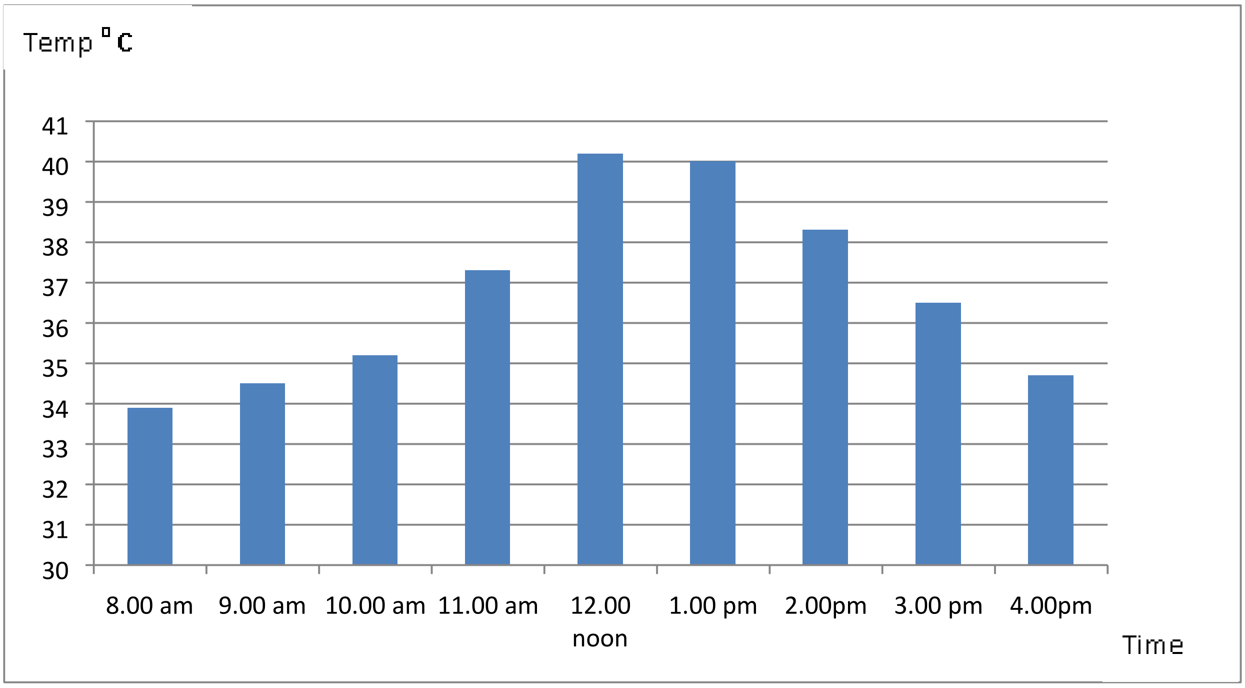
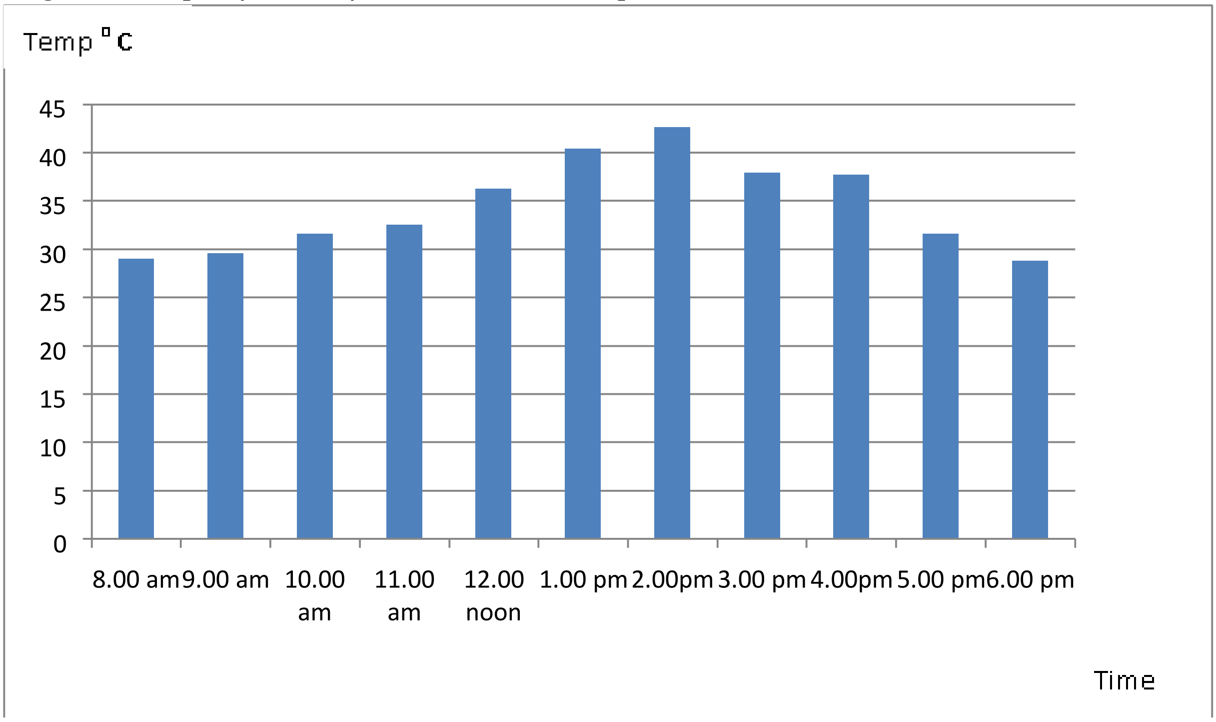


Figure 7 Graph of results from ceramic tiles experiment.



CONCLUSION

This study has been carried out in the laboratory to investigate the effect of using ceramic tiles on the walls of a building as a good mitigation model for urban heat island. Within the limits of experimental error, ceramic tiles placed at the exterior part of a building provided reduced temperature inside. It was concluded that further investigation be carried out to see the possibility of adopting and implementing this model to check urban heat island effects in our society.

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